QUANTITATIVE ASSESSMENT OF ECOLOGICAL PROCESSES AND WETLAND FUNCTIONS IN BOTTOMLAND HARDWOOD FORESTS

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INTRODUCTION

Federal agency approaches to land management have shifted from parcel-specific concerns toward a more holistic, ecosystem management approach. Southern bottomland hardwood ecosystems provide important environmental services and commodity goods, yet much of our knowledge of these systems comes from anecdotal information. The Southern Forested Wetlands Initiative (SFWI) is an interagency initiative to provide information that will form the scientific basis for ecosystem management of these systems (Harms and Stanturf 1994).

Teams of scientists from four federal agencies (Forest Service, National Biological Service, Army Corps of Engineers, and the Geological Survey) are cooperating to characterize the major biological, chemical, and physical functions of southern bottomland hardwood forests. The SFWI scientists are quantifying ecological processes and wetland functions by intensive study of representative systems on three sites. This report illustrates the approach taken with preliminary results from Iatt Creek, a minor stream bottomland in central Louisiana. Much of the user interest and research effort in ecology and management of southern forested wetlands has focused on major bottomland and swamp systems. However, the majority of remaining bottomland hardwood forests (approximately 6.5 million ha) lie within minor bottoms and drains. Preliminary results from this site will be presented on characterization of hydroperiod, ordination of overstory and midstory vegetation; comparison of decomposition and mineralization rates of leaf litter between the bottomland hardwood and upland pine environments; and avian diversity.

Site Selection

The three sites being studied were selected according to broad criteria (Harms and Stanturf 1994). Naturally vegetated bottomland hardwood forests typical of the region were sought, at least 60 years old, with no major disturbance within the last 10 years. We sought well-stocked stands with a continuous canopy (except in permanently flooded cypress communities), and we tried to ensure that all community types were represented on each site.

We sought river or creek systems with hydrology free of influence by dams or other structures, and without tidal influence. We required an unobstructed floodplain with no elevated roads, artificial impoundments, or intervening tributaries.

In order to allow study of neotropical migratory birds and accommodate silvicultural manipulations, an area needed to be about 500 ha. The landowner had to be willing to maintain and protect the site for at least 10 years. Other criteria were used to further restrict our search to sites capable of being gaged for mass-balance analysis and that would allow manipulation. Four sites were chosen, then narrowed to three due to funding restrictions: Coosawhatchie River in South Carolina; Cache River in Arkansas; and Iatt Creek

in Louisiana.

HYDROPERIOD

The Iatt Creek site is a bottomland formed by the convergence of three smaller creeks and hydrology of the site is typical of minor bottoms throughout the south. Flooding is a function of rainfall events within the drainage basin of approximately 22,000 ha. Water rises suddenly during and after major storm events. Recent debris dams suggest that normal floods cover the bottom to a depth of no more than 1 m, with 0.5 m being more common. We measure water table every 2 hrs and stream level every 15 minutes using a system of water level recorders with dataloggers. In a "normal" year, the entire bottom may flood five times, mostly in winter and spring, with the soil saturated to the surface in portions of the bottom for most of the year. The bottom has not flooded, however, in the last 13 months. Stream levels during this time show that the creek responds to rainfall events but has remained near base-flow levels during 1996.

VEGETATION

Erosion and deposition within a floodplain create a mosaic of heterogeneous site conditions over a relatively small area. Minor changes in elevation usually signal a shift in edaphic and hydrologic conditions that can result in changes in the species composition of vegetation communities. Depth and duration of flooding, and soil factors such as drainage and aeration, influence the distribution of floodplain tree species (Robertson et al. 1978). Our objective is to characterize the distribution of overstory, midstory, and understory/herbaceous species along elevational gradients between the stream from and adjacent uplands. We established seven transects aligned perpendicular to the stream channel, spaced at approximately 500 m intervals across the study area. Transects averaged 816 m long varying with floodplain width. Forty-seven, 0.1-ha ordination plots (20m x 50m) were systematically established on the transects, and each plot was subdivided into 10, 10m x 10m subplots to facilitate data collection and analysis. Ordination plots were 122 m apart and parallel to Iatt Creek.

Data were summarized into total basal areas (BA) by plot for each species, and Importance Values for each species on each plot. To illustrate species topographical relationships, elevations were categorized into 5 classes, each accounting for 20 % of the observations. Classes were < 36.4 m, 36.4 - 37.0 m, 37.0 - 37.4 m, 37.4 - 37.8 m and > 37.8 m above sea level. Importance values were calculated for each species in each elevation class.

Environmental data consisted of the surveyed elevations of plot centers. Plots were laid out to extend 50 m perpendicular to the transect from the surveyed point, so these measurements provided a crude gauge of plot elevation, but did not take into account topographical variation within plots. These measurements were transformed to the relative elevation of the plot, expressed as the height (m) of the plot above the lowest surveyed point on the transect on which the plot occurred.

Data analyses were conducted using SAS (SAS Institute Inc., Cary, NC), CANOCO (Ter Braak 1988), and TWINSPAN (Hill 1979). We used CANOCO to conduct a detrended correspondence analysis of the species BA values, and TWINSPAN to conduct a two-way analysis of species and plots to identify plot and species groupings for visual and nonparametric analysis. A Wilcoxin ranked sum test was used to test plot groupings identified in the TWINSPAN analysis.

A summary of results are presented here, and more complete discussion of these preliminary results can be found in Gardiner et al. (1996). Current forest cover is about 70-years-old or more and probably originated after logging in the early 1900s. Forty-four species were identified on at least one of the 47 plots sampled in Iatt Creek floodplain. Stand density averaged 446 stems ha^{-1}. Quadratic mean diameter of stems averaged 30.1 cm, and average

stand BA was 31.8 m^2 ha^{-1}. Thirty of the observed species occurred on at least 10% of plots. Importance Values categorized by elevation showed that some species occurred only at the highest elevations, on upland plots along the ends of the transects. Trees occurring at these elevations were typical upland species. Across the entire study area, the overstory was primarily composed of shade intolerant to moderately intolerant species such an *Liquidambar styraciflua, Nyssa sylvatica, Quercus pagoda, Quercus nigra,* and *Pinus taeda.* Shade tolerant to very tolerant species were most important in the midstory. These included *Carpinus caroliniana, Ilex opaca, Halesia diptera, Ostrya virginiana,* and *Acer rubrum.*

The results of the detrended correspondence analysis was interpreted as depicting flooding across the floodplain. The primary axis of the plot (accounting for 17% of the total variation) indicated the frequency of flooding that the species can tolerate, from no flooding for species such as *Quercus falcata,* to extensive flooding for species such as *Taxodium distichum* and *Carya aquatica.* The second axis (accounting for 4.5% of the total variation), was less clearly interpretable than the first but suggested a gradient of flooding duration. However, species like *Magnolia grandiflora, Acer rubrum* and *Quercus shumardii* do not support our interpretation, indicating that other explanations of these axes are possible. We anticipate testing these interpretations with information on the frequency and duration of flooding and soil properties that is currently being collected on the study site.

BIOGEOCHEMISTRY

The extent and diversity of bottomland forest ecosystems is well recognized (*e.g.* Christensen 1988, Hodges 1994, Putnam *et al.* 1960, Tansey and Cost 1990). Their importance from global, regional and local perspectives and their dramatic decline in area have combined to focus efforts on their preservation and reclamation (*e.g.* Hook and Lea 1989). These efforts, in turn, have identified voids in our understanding of how these systems function. One primary concern is the movement or processing of carbon and associated nutrients through these systems via the detritus pathway. Much of the past work on this topic has focused on deep water swamps or seasonally flooded areas associated with major rivers. Yet, recent analyses have shown that most of the remaining area of bottomland forest is within minor bottoms or drains (Hodges 1994).

Results are available of the initial 9 months of an ongoing 2.5 yr study assessing the difference among tree species and upland and bottomland environments in the decomposition and mineralization of leaf litter (Meier and Stanturf 1996). The objectives off this study are to compare the rates of leaf litter decomposition in bottomland and upland forest environments and to compare the rates of decomposition and nutrient mineralization in three common species of tree leaf litter that occur in both environments.

Mass loss rates of leaf litter from three major tree species that are common to both upland and bottomland forests were compared within and between upland and bottomland sites. The upland site is dominated by mature loblolly pine (*Pinus taeda)* with oak (*Quercus*) and sweetgum (*Liquidambar styraciflua*) in the mid- and understory. A mature hardwood forest, dominated by sweetgum, blackgum (*Nyssa sylvatica*), cherrybark oak (*Quercus pagoda*), and water oak (*Quercus nigra*) with scattered loblolly pine, occupies the bottomland. Decomposition rates of freshly fallen loblolly pine, sweetgum and the red oak subgenera (*Erythrobalanus*) leaf litter were compared using the litterbag technique. Litterbags were filled with pure litter from a single taxa. After 9 months mass loss in the bottomland and upland environments averaged 41% and 33%, respectively. Mass loss for sweetgum, red oak, and loblolly pine averaged 45%, 42%, and 25%, respectively.

Initial nutrient concentrations of litterfall varied significantly among all species for all nutrients. The more marked differences were between the hardwood species and the loblolly pine needles. Nitrogen concentrations in sweetgum and red oak leaves were, respectively, 2.1 and 2.3 times higher than those in loblolly pine needles. Nitrogen was the only mineral nutrient in which the concentration in red oak leaves was higher than that of sweetgum. Phosphorus concentrations were 2.8 and 2.4 times higher in sweetgum and red oak, respectively, than in loblolly pine. In base cations, Ca, Mg, and K concentrations in sweetgum and red oak leaves were, respectively, 4.8 and 3.2, 2.6 and 1.3, and 1.8 and 1.5 times greater than those of pine leaves. With the exception of Mg, nutrient concentrations in the two species of hardwood leaves were within 10-30% of each other. Concentration of Mg in sweetgum was nearly twice that of red oak. Limited lignin and cellulose analyses indicate minimal differences in concentrations among leaf litter species.

Differences between upland and bottomland communities in relative rates of mass loss were significant. A variety of studies have found more rapid rates of decomposition in bottomland communities than in upland types whether conifer or hardwood (e.g. Kelly and Beauchamp 1987, Peterson and Rolfe 1982, Shire 1986). The primary reason is generally the more mesic condition of the bottomland site. In this study, the early season flooding combined with the finer textured surface soil in the bottomland probably provided a more mesic environment than the relatively well drained forest floor and coarse textured soil of the pine upland. Moreover, the generally higher nutrient concentrations of the forest floor in hardwood bottomlands promote more rapid microbial growth (Swift et al. 1979).

The faster decay of deciduous hardwood leaf litter over loblolly pine needles is also reasonable. The much higher nutrient levels, especially N and P, of sweetgum and red oak tissue, combined with a higher leaf surface area to mass ratio in the broadleaf species (Swift et al. 1979), act to promote more rapid microbial growth and subsequent mass loss.

AVIAN ECOLOGY

Bottomland hardwood forests provide habitat for a large number of bird species, many of which are Neotropical migrant songbirds. Extensive tracts of BLH often contain substantial numbers of habitat specialists, including species dependent on forest-interior habitats. Long-term censuses of bird communities in the eastern United States indicate major declines in some Neotropical migrants, especially these forest-interior species (Johnston and Hagan 1992). Objectives of the bird research within the SFWI (Hamel et al. 1995) are to compare avian diversity and abundance among the three sites, relate bird diversity and individual species distributions to hydrologic and vegetation gradients, and monitor long-term trends in the avian communities of these wetlands focusing on breeding Neotropical migrants and wintering Nearctic migrants.

From a random point at a site, a sampling grid was established with intersections at 250 m intervals (n=44 intersections). All grid intersections were sampled once, using 5-min point counts, in May and June, 1995, the first breeding season sampled. All grid intersections were sampled once, using 10-min point counts, during December, 1995 or January, 1996, the first winter season sampled. Density and basal area of canopy tree species were measured in 0.04-ha circles centered on the counting stations (James and Shugart 1970). Analysis of variance of number of species and number of birds were conducted and mean values compared using Duncan's Multiple Range test. We calculated 95% confidence intervals around frequency of occurrence values for species recorded on at least 33% of seasonal counts.

There were a total of 1869 detections of 47 species, 805 during the breeding season and 1064 in winter at the Iatt Creek study site. Twenty-two species were Neotropical Migratory songbirds (NTMB) recorded during the breeding season only. Mean species richness of NTMB was 5.5, not

statistically different from breeding resident species richness. In the winter, mean species richness of temperate migrants was lower than winter residents. At the spring 1995 sampling, 44 species were found on the grid in the bottomland, including Great Blue Heron and Yellow-Crested Night Heron; wild turkey; Ruby-Throated Hummingbird; four species of woodpecker, Northern Parula; Pine Warbler; and Prothonatary Warbler. Additionally, five other species were observed in the bottom but not on the sample grid. Results from all three sites are compared in Hamel et al. (1996).

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SUMMARY

The Southern Forested Wetlands Initiative (SFWI), is an interagency team of scientists from the USDA Forest Service, USDI National Biological Survey, US Army Corps of Engineers, and the USDI Geological Survey, cooperating to characterize the major biological, chemical, and physical functions of southern bottomland hardwood forests. The SFWI scientists will quantify ecological processes and wetland functions by intensive study of representative systems on three sites. This report illustrates the approach taken with preliminary results from Iatt Creek, a minor stream bottomland in central Louisiana. Much of the user interest and research effort in ecology and management of southern forested wetlands has focused on major bottomland and swamp systems. However, the majority of remaining bottomland hardwood forests lie within minor bottoms and drains. Preliminary results from this site are presented on ordination of overstory and midstory vegetation; characterization of hydroperiod; comparison of decomposition and mineralization rates of leaf litter between the bottomland hardwood and upland pine environments; and avian diversity and abundance.